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(54) Solar heat collector structures

(57) A solar heat collecting structure of compact form for transport and storage while providing a large area on which solar radiation can be incident and which is particularly suitable for use as a solar fence construction to be used for example for heating of swimming pool water comprises an elongate absorber panel 1 formed of synthetic plastics material and having a plurality of channels 11 extending lengthwise thereof, the panel being connected at its ends to header tubes 2 and 3 in communication with the channels and being adapted for connection to heat exchange liquid supply means and to heat exchange liquid removal means. The panel contains at least one flexible fold *a, b, c*, extending transversely thereof whereby adjacent sections thereof may be brought into opposed parallel juxtaposition.

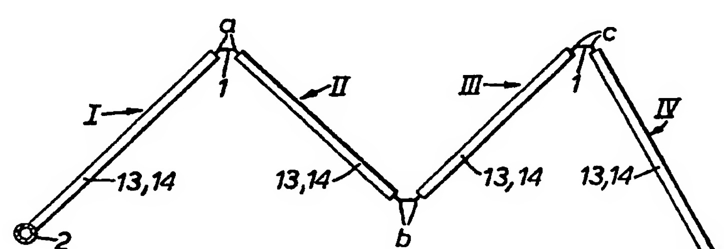

FIG. 1.

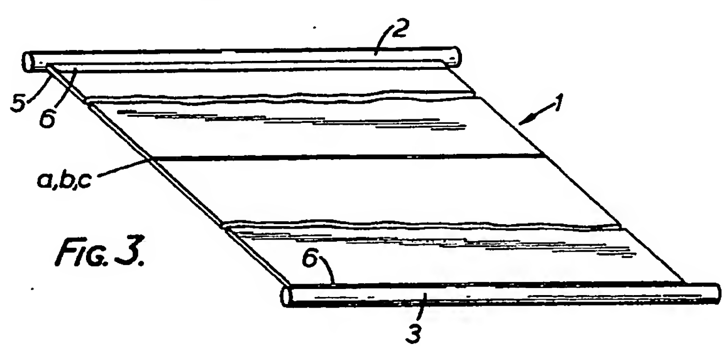

FIG. 3.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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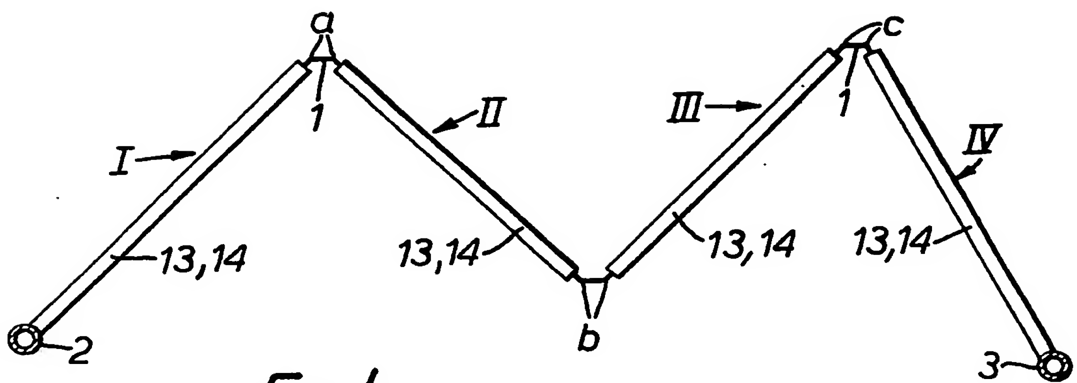

FIG. 1.

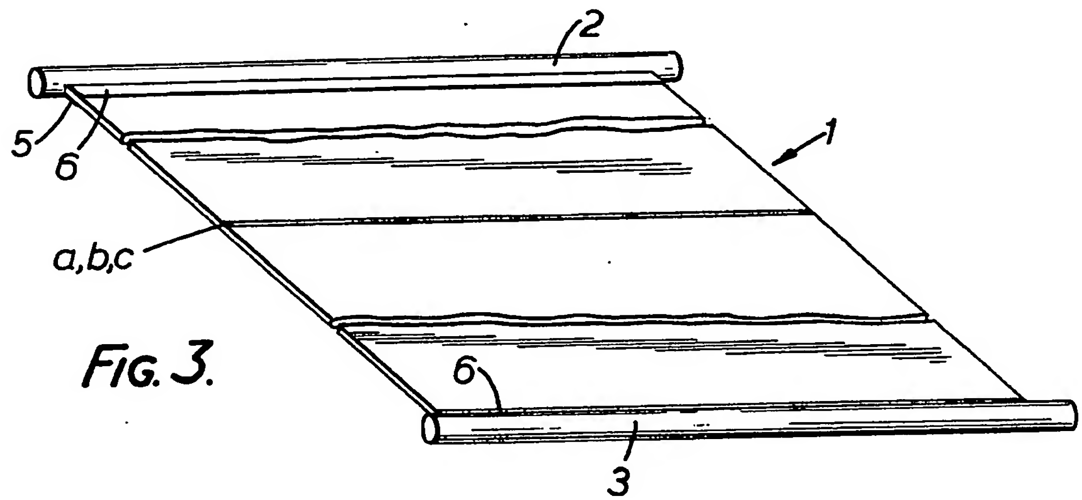

FIG. 3.

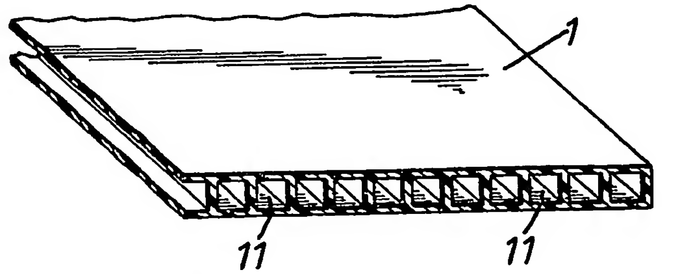

FIG. 4.

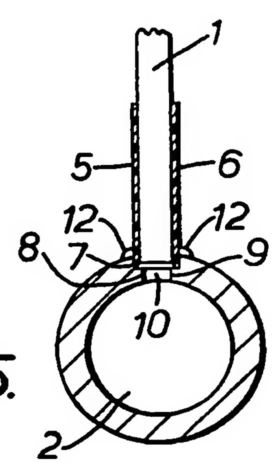

FIG. 5.

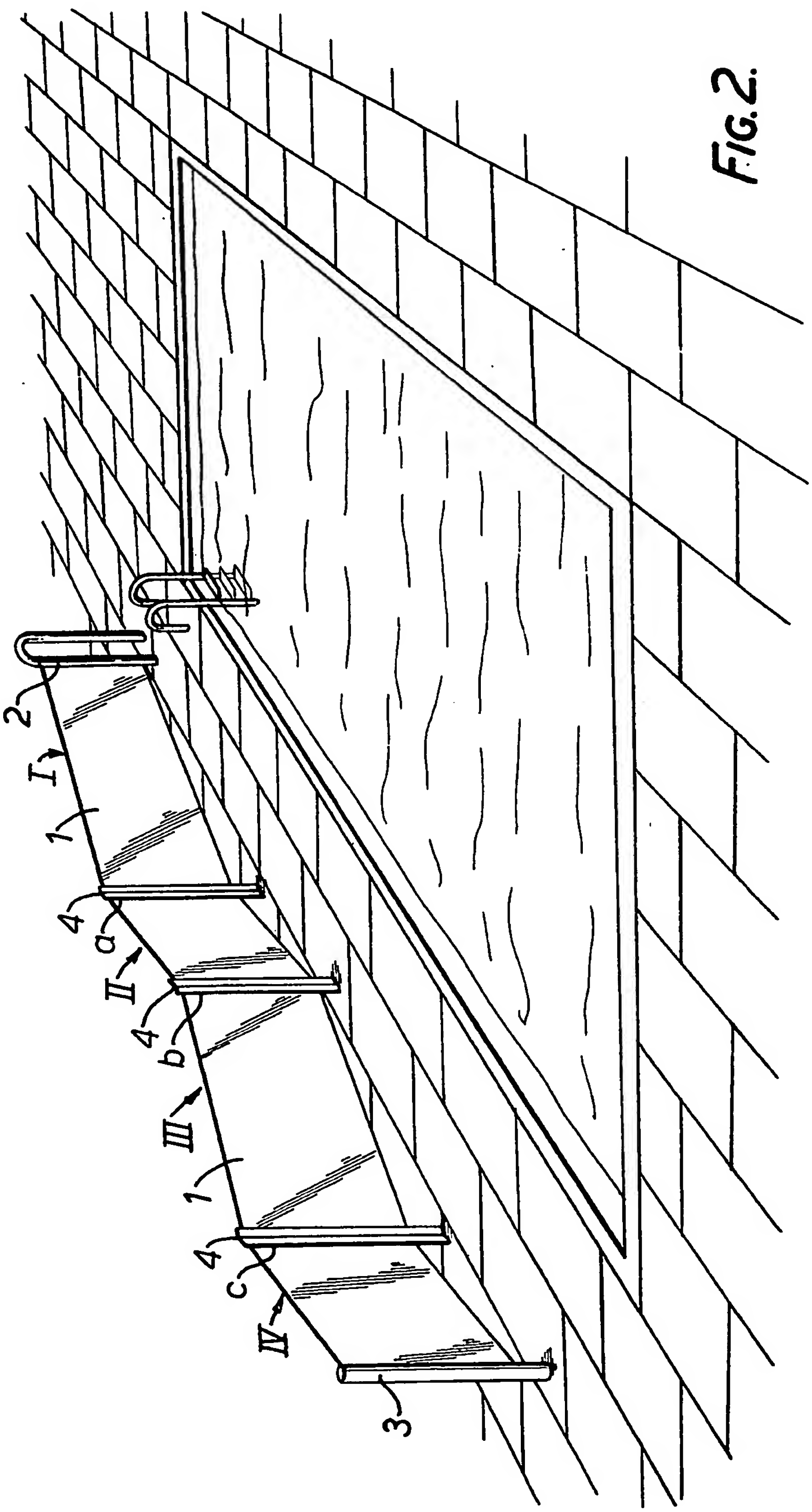

FIG.2.

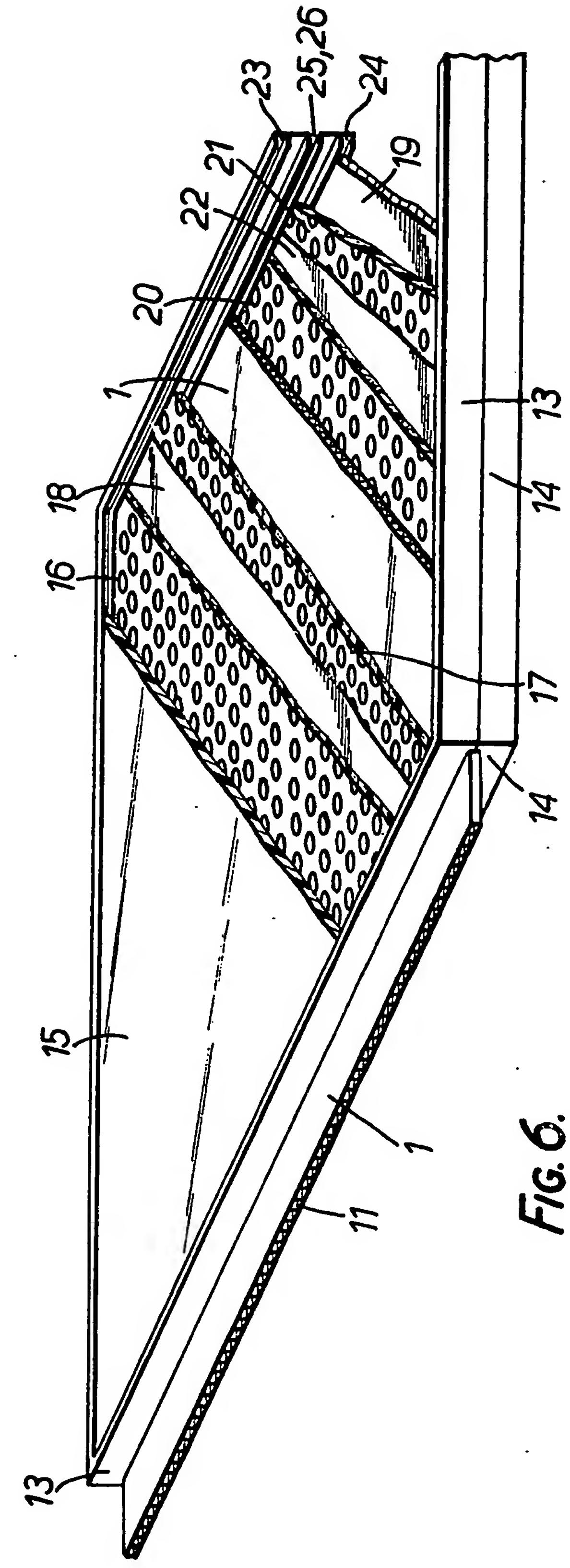

FIG. 6.

SPECIFICATION
Solar heat collector structures

This invention relates to solar heat collector structures and more particularly to solar heat collector screens.

According to the present invention, there is provided a solar heat collecting screen structure which is an elongate absorber panel formed of synthetic plastics material and having a plurality of channels extending lengthwise thereof, the panel being connected at its end to header means in communication with said channels and being adapted for connection to heat exchange liquid supply means and to heat exchange liquid removal means, the panel containing at least one flexible fold extending transversely thereof whereby adjacent sections thereof may be brought into opposed parallel juxtaposition.

A solar heat absorber panel of a solar heat collecting screen structure according to this invention is preferably formed of extruded plastics material, polypropylene being a particularly suitable material for this purpose. An alternative material which may be employed is polycarbonate. As a result of the provision of folds, it is possible to provide a solar heat collecting screen structure of considerable length and yet formed from a single panel. The fold or folds provided therein allow wrapping of the panels to take place around stakes set at intervals corresponding to the spacing part of the folds to support an upstanding screen, to prevent it from undergoing sag in a direction at right angles to the surface thereof and in a direction transverse thereof. A screen having a zig-zag configuration may thus be provided. Moreover, when adjacent sections of the panel are folded into opposed parallel juxtaposition, a compact arrangement is produced which is convenient for transporting and storage.

Hence it will be appreciated that such a construction makes it possible to achieve a reduction in manufacturing cost characteristic of panels of considerable length while achieving the advantage of avoiding an unweildy structure difficult and expensive to store, handle and transport.

If a panel is divided into three or more areas by having two or more sections by provision of two or more folds therein, then the end sections are preferably longer than any intermediate section and are not equal to each other in length. When the structure is put into a folded up configuration, the folded structure will be especially compact since the heater tubes will lie alongside one another and outside the shorter intermediate section or sections.

The headers of a solar heating collecting screen structure according to the invention and the folds provided in the absorber panel will generally be parallel to one another and extend transversely of the panel. A screen structure in accordance with the invention may be so long when fully extended as to make it inconvenient to have the fluid inlet and outlet collections at opposite ends. In such a case, it is possible to have the fluid inlet and outlet connections at the same end by partitioning the header at that end into two or more lengths and closing off the ends of the other header so that the fluid path through the panel is divided into forward and return lengths.

A solar heat collecting screen structure according to this invention is particularly suitable for use for warming swimming pool water. Because of its ease of handling and storage, it may only be desired to erect such a structure in the United Kingdom during the summer months and to disconnect the headers from supply and return means for heat exchange fluid and store it during the winter months. Because of the ease of storing the structure, which is possible because of its facility for folding, it becomes practicable to install a screen structure having an area equal to as much as that of the pool itself thereby enabling the panel to be used as the sole means of heating water for the pool so that the only running cost become the capital costs of the structure.

With a simple solar heat collecting screen structure according to the invention, the absorber panel is painted black on at least one surface to enhance the heat absorbing capacity thereof. Such an arrangement is suitable for both indirect heating of water and direct heating of water, with the latter generally being desirable when the heat collecting screen structure is employed for heating swiiming pool water. However, the heat collecting screen structure can equally well be employed in the heating of domestic water supplies when, with a view to avoidance of contamination, it will generally be desirable for indirect heat exchange to take place between the heat exchanger fluid and the domestic water supply.

Although this invention will be described herein particularly with a view to suitability for use in heating of water for swimming pools, by virtue of the ease of handling and transporting the screen structure and by virtue to the light weight thereof when empty, it is suitable also for placing on roofs for absorption of solar radiation and use thereof in the heating of domestic water supplies. It will readily be possible for a structure of considerable length to be carried up ladders to a roof area in its folded configuration and unfolded as it is laid thereon.

A solar heat collecting screen structure according to this invention may have single folds at the various folding positions or, more particularly, when the absorber panel possess substantial thickness, be folded twice in opposite directions to enable satisfactory reversing of the panel material. Such a mode of folding will be particularly desirable when a composite panel structure is employed of which the elongate panel formed of synthetic plastics material and having a plurality of channels extending lengthwise thereof forms only one element which will generally be the only element which extends the entire length of the screen structure. Particularly good heat absorption will be obtained in such a

case if additional elements of the individual sections of the overall screen structure include a window on which solar radiation is incident, in use, and which is transparent or translucent and a rear wall member parallel to the window and whose surface which is nearer to the window is capable of reflecting solar radiation. The multichannel panel formed of plastics material will extend between this window and the wall and will be transparent or traslucent with respect to solar radiation. Thermal insulation which is transparent or translucent with respect to solar radiation may be provided between the successive layers of the multilayer structure thereby produced. Such insulation material, in the case of structures for use at elevated temperatures may take the form of cellular or compartmented material, especially between the channeled panel and the rear wall. The various layers may be held together in a frame whose members extending transversely of the absorber panel are disposed at a spacing apart from the fold positions so as to allow ease of folding.

The layer of reflective material is preferably constituted by a metal foil or metallised plastics sheet.

Such a composite structure will be of particular use in permanent installations for example by providing a heated domestic water supply. The arrangement is intended primarily for heating of water by indirect heat exchange and for this purpose it is intended that a heat exchange liquid should be employed in a circuit including the elongate absorber panel, the liquid being darkly coloured to enhance the absorption thereby of solar radiation to be converted therein to thermal energy.

The heat exchange liquid may be rendered dark, for example as a result of its having a black pigment suspended therein, for example carbon black of suitable pigment size for it to remain in suspension. The heat exchange lquid may also be rendered dark by the presence of colloidal material such as graphite suspended therein. A particularly useful combination here has been found to be the combination of suspended colloidal graphite together with a dark dye, for example, a dark green dye, dissolved in the heat exchange liquid.

The use of a composite heat exchange element with indirect heat exchange using a dark heat exchange liquid is generally superior to direct heat exchange using a dark coloured heat absorber panel where heat absorption is at a surface layer only. In contrast, improved efficiency is achieved here in that because of the transparent or translucent materials employed in the construction of the window at the heat exchanger panel, solar radiation incident on the window is able to travel right across the composite structure. Some of the radiation will be absorbed by the darkened liquid as it passes through. Residual unabsorbed radiation will then be reflected back into the liquid so that relatively little will pass back out of the window of the composite structure without having undergone absorption.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, wherein:—

Figure 1 is a plan view of an erected solar heat collecting screen structure according to the invention;

Figure 2 is a perspective view showing an erected solar heat collecting screen structure according to this invention positioned adjacent a swimming pool;

Figure 3 is an isometric view of a simple solar heat collecting screen structure according to the invention;

Figure 4 is a fragmentary isometric view on a larger scale of the absorber panel material of the structure of Figure 3;

Figure 5 is a cross-section through a solar heat collecting screen structure according to the invention in the region of a header thereof; and

Figure 6 is an isometric view of a composite heat exchanger element forming part of a solar heat collecting screen structure according to the invention.

Referring to Figures 1 and 2 of the accompanying drawings, a solar heat collecting screen structure comprises a continuous single panel 1 of multichannel extruded plastics material, typically polypropylene of a grade appropriate to the intended conditions of use and which may have the extruded structure of the packaging material available in the United Kingdom from Corruplast Limited under their Registered Trade Mark "Correx". The panel 1 is disposed between header tubes 2 and 3. The panel 1 is divided into areas or sections, here four in number, I, II, III and IV, the end areas I and IV being somewhat longer than the inner areas II and III and the end areas I and IV being of slightly different length. The panel 1 is adapted to fold about transverse folding positions a, b, c, which are generally parallel to the headers tubes 2 and 3. The folds are constituted by permanent creases in the panel material produced by folding of the panel material in a folding machine. The individual sections I to IV are encased in a frame 13, 14 and form part of a composite structure to be described hereinafter with respect to Figure 6.

As can be seen particularly well from Figure 2, the solar heat collecting screen structure may be used as a "solar fence" adjacent a swimming pool. Here the individual panel areas I, II, III an IV are not encased in a frame and in a less expensive arrangement which is generally adequate for heating up swimming pool water passed therethrough. The panel areas are supported at the folding positions a, b and c by fence posts 4 which are suitably slotted or otherwise adapted to receive the panel material. Inlet and outlet connections are made to the one header 2 which is internally divided, with the other header 3 being closed off at both ends.

Generally the area of the screen structure will be at least half that of the swimming pool surface area in the United Kingdom if sufficient heating

of water is to be achieved. If an area of screen structure is provided which is particularly great, for example approaching the surface area of the pool, as may be required on occasion when insolation is poor or wind results in rapid cooling of the pool, on those occasions when the screen structure is subjected to conditions of high insolation, it may be desired to regulate the absorption of solar radiation by control of the degree of folding and hence area of the screen structure on which solar radiation is able to impinge. For example it may be desired to employ a servo-operated mechanism between the headers for altering the manner of folding of the screen structure.

The panel itself may be formed of a black pigmented material so that it is inherently radiation absorbent. Alternatively, it may be rendered absorbent by application of a pigmented surface coating. It is desirable to use a pigment which is not only absorbent over the required collecting spectrum but which is also substantially reflective, and hence non-radiant to radiation at wavelengths corresponding to absorber temperatures. In this respect, several black pigmented emulsion paints have been found to perform satisfactorily, among which may be mentioned "Brolac" PEP emulsion, jet black. Alternatively, the absorber panel may be formed of a translucent or transparent material which is internally coated with a black paint. Such modes of rendering the collector structure radiation absorbent will generally be satisfactory for those absorber panels which are to be used for direct heating of water as will generally be required with swimming pools.

Referring next to Figures 3 to 5 of the drawings, the ends of the absorber panel are secured to the tubular headers 2 and 3 by a combination of gluing and welding. Along each edge of the panel 1 there is glued a strip 5, 6 of plastics material which will generally be the same as the plastics material of the panel, for example polypropylene. This strip projects a short distance beyond the panel edge and is received in a groove 7 extending along a wall of the header 2. The strips 5 and 6 are welded to the header 2 at 8 and 9 by a conventional hot air/rod technique. A series of holes 10 along the groove 7 connect channels 11 (see Figure 4) with the interior of the header. The extension of the strips 5 and 6 across the width of the panel beyond the panel edges results in the formation of a plenum chamber so that no one channel communicates with any single hole 10 for fluid flow between it and the associated header tube. Nevertheless, insofar as Figure 2 shows an arrangement with a divided header, the plenum chamber will be closed off at a central position in correspondence with the closing off of the header tube for example by welding together of the opposed strips.

The ends of the joints thus formed between the header tubes 2 and 3 and the panel 1 are sealed off by glue injected into the groove ends and carried up along the side edges of the panel to appear as beads 12. The plenum chamber is preferably closed off by application of glue at each end to extend in the widthwise direction of about three of the panel channels. Here it should be appreciated that the panel channels in the case of the aforesaid "Correx" multichannel material have a width of about 0.5 cm and a height of about 0.5 cm.

In connecting the continuous single panel 1 to the headers 2 and 3 it has been found that when these are formed of polypropylene, it is convenient to use a silicone rubber adhesive such as the product available in the United Kingdom from Imperial Chemical Industries Limited under the trade "Silocoset", grade 152 or 153. The surfaces to be bonded should be prepared initially by thorough degreasing and application of an oxidising flame.

The use of a glued joint between strips 5, 6 and the panel 1 has been found to be a particularly effective solution to the problem of joining a relatively thin-walled material (the panel) to the relatively thick body of the header. The glued joint moreover has the virtue of accommodating stresses which are liable to be generated as a result of differential thermal expansion and contraction of panel and header following rapid changes in insolation. Where fluid temperatures are relatively low and confined to a narrow range, for example in swimming pool applications, headers and panel may be secured by an extrusion welding technique, which technique may also be used to weld strips 5 and 6 to the headers 2 and 3.

As an alternative to forming the panel 1 of polypropylene, which material has the particular advantage of low cost and flexibility thereby assiting in the folding thereof, it is also possible to employ channeled polycarbonate material which is also capable of folding to form hinged lines in a folding machine when subjected to sufficient pressure at the fold positions. Moreover, the structure of the panel itself may vary. In preferred practice, it consists of a plurality of channels lying in side-by-side arrangement and having common walls separating them. However, other products are commercially available which comprise completely separate parallel tubular panels joined by planar web sections.

A particular inexpensive solar heat collecting screen structure can be provided if an extruded plastics panel folded at one or more positions is provided between a pair of headers and is coloured a dark colour in the manner as aforesaid to assist in achieving direct heat exchange. Although the channels are pinched at the position of the folds, this is not a handicap to the satisfactory operation of the screen structure since it has been found that, when subjected to quite small liquid pressure, the channels, even though the panel is in a folded condition, are opened out at the fold positions and flow of heat exchange liquid is not hampered.

This latter feature is also applicable when screen structures according to the invention are utilised for heating of domestic water supply when

it will generally be preferred for indirect heat exchange to take place. Here, because of the permanent nature of the installation which will be required, it is preffered to employ a screen structure wherein individual sections such as I, II, III and IV in Figure 1 have the construction shown in Figure 6 of the drawings. Here, each individual section of the panel 1 is encased in a composite structure which will be of such thickness that in fact a double fold will be required at each folding position in the panel, as Figure 1 shows. At each section of the screen structure, the panel 1 is fitted within and extends from within a two-part housing frame 13, 14. At the front of the composite structure held together by the frame 13, 14 is a window 15 formed of transparent polycarbonate plastics material which may be the same channel-form polycarbonate plastics material as used for the panel 1, for example the product available in the United Kingdom from Corruplast Limited under the TradeMark "Correxine". This material combines the requisite properties of physical strength and toughness with resistance to degradation by ultraviolet light and selectivity of transmission and reflection.

Between the window 15 and the panel 1, there are two layers of convection-current reducing insolation material 16 and 17, each of which may conveniently consist of a sheet of the product "Aircap" (Registered Trade Mark) providing a layer of plastics encased air bubbles of uniform size. This material is generally available for packaging purposes and is made from thin transparent polyethylene. Its insulating properties have been shown by tests to be superior to those of expanded polystyrene and moreover this product permits transmission of the useful part of the sun's radiation. Moreover, it is less expensive and lighter for a given volume than expanded polystyrene. One form of the product "Aircap" which has been found to be suitable is the product "D 120" which has bubbles 3.17 cm in diameter and 1.27 cm high.

Between the two insulating layers there is provided a thin sheet 18 of clear polyethylene terephthalate plastics film available in the United Kingdom under the Trade Mark "Melinex" from Imperial Chemical Industries Limited. The sheet 18 at this location serves as a reflector in the deep infrared region of maximum re-radiation from the panel 1 when the latter has become warmed up. The optical properties of this polyethylene terephthalate plastics sheet moreover make this material a satisfactory alternative to the polycarbonate for the window 15, although the latter is preferred on account of its mechanical strength.

As an alternative to utilising insulation layers 16 and 17 on the one hand and the polyethylene teraphthalate sheet 18 on the other hand to achieving the functions of convective insolation and deep infrared reflection, these functions can be combed in one material if polethylene terephthalate sheet material is produced in a cellular or otherwise compartmented form. Insulation may be improved further by filling the compartments of such material or bubbles of the aforesaid "Aircap" material with a heavy gas such as nitrogen or krypton which has a lower thermal conductivity than air. Behind the panel 1, lies a backing sheet 19 which may be formed of plastics material, plywood hardboard or other sheet material which is preferably selected for its strength. It is nevertheless also possible to employ extruded polypropylene, for example the material from which the panel 1 is formed, although this will not have the same strength. Between the panel 1 and backing sheet 19 there are disposed two further insulation layers 20 and 21 which are preferably of the same material as the insulation layers 16 and 17. A sheet 22 of metallised plastics material or metal foil is disposed between the insolation layers 20 and 21 to act as a total reflector of radiation from the panel 12 and to reduce radiation from the insolation material which will have become warmed up in use of the screen structure. This latter function may be supplemented by provision of a further sheet, not shown, constituted by a specular reflector disposed adjacent the backing sheet and having its polished face outwards.

The housing frame 13, 14, may be formed of extruded polypropylene having multiple flanges to form two channels 23 and 24 to receive respectively the edges of the window 15 and the backing sheet 19 and defining between the parts 13 and 14 of the housing at opposite sides of the frame slots 25 and 26 for allowing through passage of the panel 1. The window and the backing sheet are secured by plastics fastenings (not shown) and are preferably sealed in position to weatherproof the assembly. Improved weatherproofing is also achieved by mitring of the corners of the frame and welding the frame side members together by a heated plate welding technique.

This composite structure may be simplified for relatively low temperature applications such as the warming of swimming pool water. Here it is possible to dispense with the convective insulation and to provide a compact "sandwich" structure in which the various layers (panel 1, window 15, infrared reflector 18, total reflector 22 and backing sheet 19) are held together by channel section edging strips.

The form of construction described with respect to Figure 6 of the drawings is particularly suitable for use with darkened heat exchange liquids, that is in an indirect heat exchange system, because of the particularly efficient absorption of solar energy made possible by the composite construction of the screen structure within the confines of the individual panel sections.

CLAIMS

1. A solar heat collecting screen structure which is an elongate absorber panel formed of synthetic plastics material and having a plurality of channels extending lengthwise thereof, the panel being connected at its ends to header means in

communication with said channels and being adapted for connection to heat exchange liquid supply means and to heat exchange liquid removal means, the panel containing at least one flexible fold extending transversely thereof whereby adjacent sections thereof may be brought into opposed parallel juxtaposition.

2. A structure as claimed in Claim 1, wherein the panel is formed of extruded polypropylene.

3. A structure as claimed in Claim 1, wherein the panel is formed of extruded polycarbonate.

4. A structure as claimed in Claim 1, 2 or 3, wherein a plurality of folds are formed in the panel, successive folds being in opposite directions whereby the panel assumes a zig-zag configuration when unfolded.

5. A structure as claimed in Claim 4, wherein end sections of the panel formed by folding are of longer length than intermediate said sections, with one end section being longer than the other.

6. A structure as claimed in any one of the preceding claims, wherein fluid is to flow forward through one portion of the panel and then back through another portion of the panel, in which structure parallel header tubes extending transversely of the panel are provided at the respective ends thereof, one header tube being divided in two, with one part being adapted for connection to said liquid supply means and communicating with said one portion of the panel, and the other part being adapted for connection to said liquid removal means and communicating with said other portion of the panel, and the other header tube being closed off from communication directly with the exterior of the structure and serving to place said one portion of the panel in communication with said other portion of the panel.

7. A structure as claimed in any one of the preceding claims, having at least one surface of the panel painted black.

8. A structure as claimed in any one of Claims 1 to 6, wherein sections of the panel between folds or between folds and header means form part of composite panel structures, each composite panel structure comprising a window on which solar radiation is incident and which is transparent or translucent, a rear wall member parallel to the window and whose surface which is nearer to the window is capable of reflecting solar radiation, and the panel section therebetween, the panel being transparent or translucent with respect to solar radiation.

9. A structure as claimed in Claim 8, which comprises thermally insulating material which is transparent or translucent with respect to solar radiation disposed between successive elements of the composite panel structures.

10. A structure as claimed in Claim 9, wherein the thermally insulating material is formed of cellular or compartmented plastics material, the cells or compartments of which contain gas.

11. A structure as claimed in any one of the preceding claims, wherein two folds in opposite directions are formed at the or each fold position.

12. A structure as claimed in any one of Claims 8 to 11, when forming part of an installation for heating a supply of water by indirect heat exchange thereof by liquid which has flowed through the panel, duct means connecting liquid removal means with said liquid supply means in a closed system containing said liquid, said liquid being darkly coloured so that solar radiation incident on a said window is able to pass through the heat exchange liquid in a said panel section and be substantially or completely absorbed thereby either before reaching the rear wall member or after reflection thereat.

13. A solar heat collecting screen structure substantially as hereinbefore described with reference to and as shown in, Figures 1 to 15 of the accompanying drawings, optionally modified as described with reference to, and as shown in, Figure 6 of the accompanying drawings.

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